

Method for measuring parameters and a striking device

The invention relates to a method for measuring and computing parameters upon striking an object to be moved, such as a ball, at a hitting location on a striking surface of a striking device, such as a tennis racquet, in which at least one sensor system comprising at least one sensor, which system is attached to the striking device, delivers signals to a computer, which computes at least the velocity of the object being moved and/or the velocity of the striking device from said signals, which velocity is presented on one or more presentation devices.

US patent No 6,134,965 describes an apparatus for deriving a parameter, in particular the velocity at which a ball is being struck, i.e. the sum of the velocity of the ball and the velocity (in opposite direction) of the racquet, from the vibrations of the racquet strings.

German Patentschrift No 34 36 218 describes an apparatus for counting the number of strokes with a striking device, which apparatus comprises a contact foil that is present in or near the striking surface of said striking device.

European patent application No 0 407 631 discloses a method for testing that tennis racquet.

The object of the method according to the invention is to improve the method referred to in the introduction, and to that end it comprises the features defined in claim 1 or claim 2. The invention makes it possible to determine the velocity of the striking device itself during a swinging movement and/or at the time of an impact by measuring the acceleration, in particular the acceleration in centripetal direction.

Preferably, an enumeration both the overall number of strokes and of the number of good and bad strokes that have been played is given when using the method according to the invention for the purpose of improving the player's performance, to which end this preferred method is characterised

in that the sensors measure the acceleration of the swing of the striking device and register whether an impact with the ball takes place on the front side or on the rear side of the striking device.

5 From US patent No 5,816,580, for example, there is known a paddle having a striking surface on either side, on which a sensor is present for measuring the impact with a bat and delivering a relevant signal to a counter. The intention of the game is to return the ball while using a different
10 side for each stroke. The counter registers that a mistake has been made, in which case the opponent scores a point. This registration thus has nothing to do with games in which it is the game position that determines whether to use a forehand or a backhand stroke.

15 In a further development of the method according to the invention, not only the acceleration but also the magnitude and the frequency of the vibrations caused by the impact in at least one direction, preferably in two or three directions perpendicular to each other, are measured in order to
20 determine which impact position on the striking surface causes the lowest amplitude vibrations and is thus the most effective.

 The invention furthermore comprises a striking device, such as a racquet, a bat or a stick in accordance with
25 claims 6 - 8.

 Preferably, the accelerations experienced by the sensor are fed to a computer in the form of as many signals during each of the successive strokes, which computer is connected to a presentation device, on which the changes in the
30 acceleration during the swing and upon impact during said successive strokes can be displayed. In this way it is possible to provide the player with accurate information as to his good and his bad shots, which will enable him to adapt his technique in a positive sense.

35 It is noted that from US patent No 5,351,952 there is known a method for matching golfer to golf club, in which the swing time of a golfer is measured and a golf club having the inverse of four times its natural frequency ap-

proximately equal to the golfer's measured swing time is selected for the golfer.

The invention makes it possible, depending on the specific embodiment, to take into account a number of important factors, such as velocity and acceleration of the striking device, the spatial direction of the striking device as a function of the direction in which the object to be moved hits the striking surface of the striking device and the angle of the striking device relative to the hitting location.

The above and further aspects of the invention will be explained in more detail hereinafter with reference to the figures, which show an example of one of the possible methods and apparatuses according to the invention.

Fig. 1 shows a tennis racquet in the forehand position, which racquet comprises a housing formed on or in the handle, which housing accommodates a sensor system.

Fig. 2 is a schematic representation of the electronic processing of the received signals.

Fig. 3 is a graphic representation of centripetal forces and the impacts of the ball on the racquet.

Fig. 4 is a graphic representation which shows the vibrations on the racquet in the case of a "good" hitting location and in the case of a "bad" hitting location.

The tennis racquet 1 comprises a striking surface 2 consisting of strings, whose front side or rear side can be used for hitting a ball, the choice between the two sides being determined by the game position. To that end, the racquet undergoes a swinging movement W, in this case drawn in the position in which the front side of the striking surface is used, during which movement the racquet experiences a centripetal force. The magnitudes of the accelerations that occur in the X-, Y- and Z-directions are measured by a sensor system 3, which is mounted in or near the handle of the tennis racquet 1 or, preferably, in or near the tip of the tennis racquet 1. The sensor system comprises one or more piezoelectrical accelerometers and delivers corresponding signals to a computer, for example a microcomputer accommodated in the handle, which is connected, either by means of a signal

conductor or wirelessly, to a remote presentation device (not shown), such as a display screen, an X-Y writer or the like, or to a mini screen or the like mounted on the racquet.

Since the acceleration, in particular in the "Z"-direction can reach a value of 2000 G, whereas only small accelerations (about 2 G) occur for registering the hitting locations or position changes from forehand to backhand, it is preferable to use separate sensors, whose degree of sensitivity is geared to accommodate said extreme differences in the acceleration values.

Figure 2 schematically indicates the electronic path along which the signals from the three acceleration sensors 3x, 3y, 3z are supplied, via signal amplifiers 4 and an analog/digital converter 5, to a microprocessor 6, which is connected to a storage/memory 7 on the one hand and to a presentation device, such as a PC 8, on the other hand. Control buttons 9 can be used for making a selection from the various images that are to be displayed, for example after a match or after a series of strokes.

The signals being received are converted in the computer, so that the following information can be provided on the presentation device:

- the interval of time between the successive strokes;
- the velocity of the racquet prior to hitting the ball;
- forehand or backhand;
- service stroke (yes, no) and velocity of the service;
- the maximum amplitude of the vibrations;
- the maximum acceleration in the "Z"-direction (a measure of the velocity of the ball);
- the hitting location of the ball on the striking surface of the racquet;
- the number of strokes per unit time;
- the total number of strokes;
- indications "in" or "out".

This information enables the player or the trainer to get an impression of the quality of the player's game by analysing a large number of different technical aspects and furthermore to find out which techniques of the game require adaptation or improvement.

The forces along the three axes C_x , C_y , C_z as well as the impacts B are schematically and graphically represented in Fig. 3, which clearly shows the magnitudes of the various accelerations associated with said successive impacts. The rotational speed of the tennis racquet 1 about an effective centre of rotation, which is e.g. located between the player's wrist and elbow, can be determined on the basis of the centripetal force C_y .

Fig. 4 clearly shows the difference between a stroke that generates strong vibrations, which occurs when the ball hits a striking surface at an incorrect position thereon, and a stroke that generates relatively mild vibrations, which occurs when the ball hits the striking surface at a correct position thereon.

Using the game data that can be obtained by means of the apparatus according to the invention, it is possible to combine the timing data with the acceleration data. All kinds of information/conclusions can be derived on the basis of heuristics by measuring the interval of time between successive strokes. Assuming, for example, that the player is serving and the ball is out, it is practically certain that the player will hit a new service within 3 to 5 seconds, without other types of strokes being hit in the meantime. In other words: all kinds of conclusions can be drawn on the basis of knowledge of the game (the rules), the types of strokes and heuristics. In the aforesaid case, for example, it is readily possible to determine precisely the number of first services that were in, the difference in velocity between the first and the second services and the number of services directed at the opponent's forehand and backhand, respectively, after the game. (Player A serves, player B receives the ball one-tenth of a second later).

Furthermore it is for example possible to combine the data registered by one of the sensor systems according to the invention, which are attached not only to the bat but also to the wrist or the hand of a baseball pitcher, and the angular displacements and accelerations and parameters further derived therefrom.

In this way it is for example possible to measure what kind of pitch shots (velocity and type of effect) are proving to be the most difficult for the batsman.

Furthermore it is possible, of course, using the apparatus according to the invention, to have the computer give the player directions (so-called direct teaching), e.g. by means of an acoustic signal, during a game or during a training session.

The methods according to the invention enable the sporters to train more efficiently. For example, they may be instructed to pay some extra attention to their backhand service return during a training session.

The coaching or training information might also be communicated during the training session by means of a speech generating module connected to the computer. The computer and the speech generator might operate separately from the bat or be integrated therein.

It stands to reason that if the position of the racquet relative to the court is also registered, the location where the ball will hit the court can be computed in an acceptably precise manner on the basis of the velocity of the ball in combination with the location where the ball makes contact with the racquet, whilst it can also be derived from said measured place on the court whether the ball was in or out and, for example, whether the ball has been played with topspin.

The method according to the invention makes it possible to store the above and other game situations in the memory of the computer and visualise these data at any desired moment, for example for evaluating a training session or a match.